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Health Implications of Increased Coal Use in the Western States

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The National Energy Plan proposed by President Carter provides for the rapid development of coal resources in the United States, particularly in the West. The potential consequences for health of this development were considered by the Advisory Committee on Health and Environmental Effects of Increased Coal Utilization, reporting to the Department of Energy. Their report recommended rigid adherence to pertinent existing regulations, improved environmental monitoring, expanded research in selected relevant topics and development of procedures for selecting the sites of new coal-fired power plants. Although the report was a major exercise in technology assessment, it is fundamentally a cautious document that proposes no new solutions or approaches. A review of occupational and community health problems associated with coal mining and coal utilization suggests that lessons from past experiences, especially in Appalachia, cannot be applied to the West uncritically. The two regions are fundamentally different in scale, topography and social development. In the West, future problems related to coal are likely to derive from unknown risks associated with coal processing technologies, land reclamation and water quality at the sites of power generation, and extensive social and demographic changes at centers of industrial activity that may have secondary effects on health. Additional considerations should supplement the recommendations of the Advisory Committee report.

A MAJOR COMPONENT of the National Energy Plan proposed by President Carter is the rapid development of American coal resources. The conversion of industries and utilities from oil to coal as a source of energy is already well under way.[1]

When petroleum dominated the national energy budget, little incentive existed to invest in new coal mines or to expand the capacity of existing coal-handling facilities. With the current new wave of interest, the push is on to develop previously unmined coal fields in the Western states. Most of this coal will be used to supply utilities serving Western cities.[2] Such a massive shift in energy production will have far-reaching effects on the region. Among the most important but least predictable of these effects will be the impact on health in the West.

An economic activity of this magnitude is

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ABBREVIATIONS USED IN TEXT

CWP = coal workers' pneumoconiosis (black lung)
PMF = progressive massive fibrosis

bound to have potential consequences for environmental and occupational health. Although there is no accepted systematic methodology for assessing the probable effects of introducing such a technology into a region on a massive scale,[3] preliminary plans must be made by federal and state authorities to anticipate problems. The Department of Energy has had the assistance of a panel of advisors chaired by Dr. David Rall, Director of the National Institute of Environmental Health Sciences. This Advisory Committee on Health and Environmental Effects of Increased Coal Utilization recently published its final report in the *Federal Register*.[4] The document is a major effort in technology assessment and is well worth studying critically.

The Advisory Committee report recommends several federal measures to minimize the emergence of health problems resulting from expanded coal utilization in the United States. These are summarized below:

- Require rigorous adherence to federal and state air, water and solid waste regulations with the universal adoption and operation of the best available control technology.
- Require rigorous adherence to reclamation standards and sponsor small-scale demonstration projects.
- Require rigid adherence to mine health and safety standards, development of a systematic health monitoring and assessment program for mine workers, and close monitoring of training and safety programs for new mines.
- Improve environmental monitoring and data collection in the United States.
- Expand research programs in (1) air pollution chemistry, distribution, toxicology, (2) the atmospheric effects of carbon dioxide, (3) acid fallout (from air pollution) and its biological effects and (4) the migration of toxic trace elements.
- Develop procedures for the *judicious* siting of coal-fired facilities.

The Advisory Committee report was an important exercise in technology assessment and environmental health. The main thrusts of the recommendations are to support the enforcement of existing regulations and to urge further research. While this provides useful support to agencies and individuals presently struggling with a difficult and complex problem, nonetheless it urges a cautious policy that misses many opportunities for creative new solutions and for public education and participation. Such creative approaches suggest themselves after a critical review of health problems associated with coal mining, coal combustion and coal-dominated communities.

TABLE 1.—*The Magnitude of the Expansion of Coal Mining in Far Western States*[5,6]

State	Number of Existing Mines*	Number of Planned New Mines	Annual Coal Production†	Increases in Production
Arizona	2 (0)	0	10.2	5.0
Colorado ...	33 (18)	37	9.4	45.6
Montana ...	8 (0)	6	26.1	48.2
New Mexico .	5 (1)	3	9.8	77.7
North Dakota	10 (0)	5	11.1	42.6
Utah	20 (20)	25	7.9	64.5
Washington .	4 (1)	2	4.1	2.0
Wyoming ...	20 (5)	23	30.9	139.8
Total, 8 states	102 (45)	101	109.5	425.4

*Numbers in parentheses indicate underground mines; remainder are strip mines.
†Annual production in millions of short tons per year. A short ton, the industry standard measure, is very nearly equal to a metric ton, or 1,000 kg. Data are current for 1976.

Background to the Problem

To understand the potential importance of health problems associated with increased coal extraction and utilization in the West, one must appreciate the magnitude of the economic commitment.

The estimated increase in coal mining activity in eight Western states is tabulated in Table 1 from data compiled by the Bureau of Mines.[5,6] Between opening new mines and expanding production in existing ones, present plans call for adding almost half a billion short tons (a short ton is almost equal to a metric ton, 1,000 kg) every year for most of the next ten years. Strip mining will predominate throughout the Western coal fields except in Colorado and Utah, where most new mines will be underground. Thus a substantial work force will be exposed to a new set of occupational hazards in the region. Most of the coal mined in the West will be used there by Southwestern utilities and heavy industry.[2] The increase in coal utilization and the introduction of strip mines into a very different ecological

setting raise the possibility of occupational risks and environmental health problems in Western coal communities.

Coal Mining: Occupational Risks

Much less is known about the occupational health effects of strip mining than of underground mining, but this probably reflects the lack of urgency in the past because underground mining has been conspicuously more dangerous. One would expect that strip mining would result in less dust exposure and that the risk of trauma would be less, so that the occupational health risks are probably more akin to those of a quarry or dam construction site. Because of these differences and the improving technology for dust control, one cannot simply extrapolate from the mining experience of Appalachia to the West. Nonetheless, a brief consideration of the known health problems associated with coal mining will provide a framework for discussion.

Patterns of morbidity and mortality among coal miners and residents of coal mining communities have been reviewed in detail recently and will be summarized only briefly.[7]

Coal miners have a life expectancy and overall mortality from all causes that are similar to those for the general adult male population.[8] Paradoxically, this is cause for concern because the selection pressure of their strenuous occupation would be expected to result in a lower mortality than for men in general, a phenomenon known in occupational epidemiology as "the healthy worker effect."[9] This finding suggests a possible aggregate excess mortality that is countering the effect of selecting a population of workers sufficiently fit to perform physically demanding work.

Examining mortality rates by specific causes compared with rates for the general adult male population, coal miners have an increased incidence of mortality from several causes—particularly trauma, respiratory diseases and cancer, chiefly of the stomach. (Lung cancer does not appear to be an occupational hazard for coal miners.[7,10]) Tuberculosis rates in the general population of Appalachia, which has been the principal coal mining region of the United States, have been high for many years, so that reports of elevated risk for death from this cause among coal miners should not be considered as proof of an occupational risk in the absence of silicosis.[7]

The principal respiratory diseases of coal miners are not limited to coal workers' pneumoconiosis (CWP, commonly called black lung), although this is their characteristic occupational disease. Miners are also at risk to develop silicosis, especially if they are involved in mine construction or in certain jobs that require rock drilling. A chronic, irritative bronchitis may develop which has been called industrial bronchitis.[11] CWP itself is a clinical and radiologically diagnosed condition which is classified as *simple,* in which case its functional significance is usually negligible, or *complicated.* Complicated CWP is the radiological description of the pathological finding of progressive massive fibrosis (PMF), in which increasing pulmonary fibrosis forms enlarging nodules and an obliterative endarteritis. Complicated CWP, or PMF, can result in severe respiratory impairment and cor pulmonale, and should be considered a potentially life-threatening disease.[7,11]

There are certain helpful studies that have indicated general regional trends: Underground coal miners in Utah and Colorado have a much lower prevalence of simple CWP than Eastern miners of comparable age and experience, and little or no complicated CWP (PMF).[11] The rank (quality grade) of coal in the West is bituminous or lignite, the dusts of which appear to be much less dangerous than that of anthracite, which predominates in Pennsylvania.[7,11] The dust exposure of surface workers at underground mines is probably comparable to that of strip mine workers. Surface workers have a much lower prevalence of CWP and less frequent abnormalities on pulmonary function tests than underground miners.[11,12] One may, therefore, expect relatively little occupational respiratory disease due to coal mining in the West as long as present safety and health standards are met. *Industrial bronchitis* might be the most likely problem of the three respiratory diseases of coal mining.[7,11] Trauma is likely to be the single greatest occupational hazard. Too little is known of increased cancer mortality to project a trend.

The production of energy from coal in the future will probably not be based on simple combustion of the mined product. Intermediate processing will convert the coal into a form that is more efficient and convenient to transport. The two principal candidates for this intermediate role are gasification[13] and liquification.[14] The National Institute of Occupational Safety and Health has already issued preliminary recommendations for standards to protect worker health in pilot coal gasification plants, but these are largely extrap-

olated from other, similar industrial processes and are not based on new data.[15] Coal liquification is not as far along in its technical development and a full-sized pilot plant does not exist yet in this country.[14] Liquified coal contains an enormous variety of organic compounds reflecting the biological origins of the material,[16] some of which are likely to be toxic or carcinogenic.[15] The toxic hazards posed by the coal processing technologies cannot be adequately anticipated at present. The products of both processes are complex mixtures of aliphatic and aromatic hydrocarbons, sulfides, organic metal compounds, carbon monoxide, and other substances. The processes involve varying degrees of physical containment and hence different risks of exposure. The state of the engineering art is rapidly advancing and with it the compositions of the products and the risks of exposure are changing. Past studies and the experience of other related technologies are uncertain guides to the future risks.[15] Therefore, both technologies deserve close observation to anticipate risks to the health of workers and residents of the local communities in which these plants are to be located.

In summary, occupational health risks resulting from expanded coal mining in the West are unlikely to be as great as they historically have been in the Appalachian experience. Coal processing technologies deserve further study because their risks are not known.

Coal Mining: Community Risks

Community health problems resulting from coal mining may be mitigated by the remote location of most mines. Groundwater contamination by mine seepage could become a serious problem in semiarid regions where alternative sources do not exist and where the water quality may already be poor.[7] The surface water in areas of heavy bituminous mining tends to be acidic and high in sulfates, iron, calcium and trace elements.[17] Substantial treatment may be required to render such water potable if the runoff contaminates groundwater sources or aquifers used by local communities. Many of the mines will be located in arid and semiarid regions where they will compete with local communities for the use of limited water supplies for coal processing and for slurry-mixing to transport coal by pipeline.[18] Dust fallout from nearby mines is bound to occur as well.

The sites of excess cancer mortality among residents of Appalachian communities includes stomach, lip, mouth and throat.[7] Although these are sites that could plausibly be related to an environmental exposure, the risk may result from the common habit of tobacco chewing.[19,20] One cannot predict that coal mining per se will introduce an environmental risk of cancer.

Local community health problems, therefore, may relate primarily to water quality in areas of active coal mining. These problems may be minimized by appropriate reclamation procedures, by protecting area aquifers against contamination by runoff, and by avoiding the construction of residential communities adjacent to or near the mines. Most likely the more significant community health effects of coal mining would be secondary to demographic changes, such as those described below.

Coal Utilization: Community Risks

A major legal and political battle over coal utilization in the Southwest preceded the present rush of interest, but highlighted all of the basic issues. In 1971 a consortium of Southwestern utilities sought to expand power production by developing the enormous Black Mesa strip mine in northeastern Arizona to supply a series of huge power plants in Utah, Arizona, Colorado, New Mexico (collectively called the Four Corners area) and Nevada. The electricity generated was to have been used primarily in Los Angeles, San Diego, Las Vegas, Phoenix and Tucson, and the project would have created thousands of new jobs.* The plan was bitterly opposed by environmentalists and by certain segments of the Hopi and Navajo tribes on grounds of ecological degradation, public health, water rights and religious freedom (the mine occupies sacred tribal land). At the same time, serious questions were raised regarding the benefit of economic development weighed against the risks to health and to the quality of life in the area. The then Executive Director of the Arizona Tuberculosis and Respiratory Disease Association intuitively characterized the demographic implications of the new industry as follows:[21]

Small cities and towns dot the Southwest, charming communities in which to live. Many of the young people who

*Environmental Impact Statements on various phases of the proposed power grid sponsored by the Western Energy Supply and Transmission Association (a consortium of 23 utilities) were filed by the U.S. Bureau of Reclamation, Salt Lake City, 1971, covering the Black Mesa mine, the Navajo Project, the Huntington Canyon Generating Station and Transmission Line, the Navajo-McCullough Transmission Line, and the Navajo-Black Mesa Coal Haul Railroad.

resided in those towns have abandoned them because of the attractions of urban living. Remaining in these towns is an older population. Obviously, the older population is that segment where chronic diseases are most prevalent. They are labelled susceptible. If anyone suffers from adverse effects of air pollution, it will be the older citizen, the susceptible, as well as the American Indian.

The prolonged legal and political dispute ended with the sharp curtailment of the planned power network and cancellation of many units. Even so, the Black Mesa mine continues to deliver about 5 million tons of coal annually to power plants at Lake Mojave, Nevada, and at Page, Arizona.[5]

With such a legacy of conflict, it is surprising that many of the primary belligerents in the Black Mesa/Four Corners battle are now collaborating in the National Coal Policy Project, an effort to find common ground and agreement between environmentalists and industry leaders.[22]

The increasing use of coal combustion to generate electricity will threaten air quality gains in some areas[4] because new coal-burning utilities will be located near population centers rather than near the coal beds.[22] Significantly tighter emissions control standards may be required in the future to maintain air quality at present or improved levels despite increasing combustion by power plants and factories.[23] Recent studies by TRW, Inc., and the Electric Power Research Institute have concluded that the basic technology for coal-burning power generating stations will probably remain substantially the same over the next two decades except for the introduction of intermediate processing. If so, future standards will have to be met by emissions control devices rather than by fundamental changes in the design of the plants. The technologies for removing the oxides of sulfur and particulates from stack emissions are further refined than the technology for removing the third major class of air pollutants encountered in this setting, the oxides of nitrogen. The latter pollutants are likely to be the most stubborn problem in emissions control.

Recent data suggest that the earliest health effects of the oxides of nitrogen in ambient air may be very subtle, such as an increase in the frequency and severity of respiratory tract infections.[24] Furthermore, the combustion products of lignite (brown coal), which is increasingly being utilized for power in Texas,[25] may contain more than 22 elements, including quantities of lead, mercury, cadmium and zinc. Electrostatic precipitators vary in the efficiency of removal of these metals, each of which may have subtle toxic effects.[26] Yet another compelling reason for enforcing strict emissions standards is the recent demonstration of mutagenic (and potentially carcinogenic) substances in respirable particles of fly ash from an electrostatic precipitator in a modern coal-fired power plant.[27] It would be prudent to keep exposure to such substances to an absolute minimum among workers and the general population. Airborne emissions from modern coal-fired facilities may release radionuclides at levels significantly above background levels but low enough that any conceivable health effect would be impossible to detect.[28]

There are no available studies rigorously examining the health effects of a modern coal-fired power station on its local and service communities. A major, large-scale, multiple-site study was recently proposed to compare the impact on community health of conventional fossil fuel and nuclear facilities. Such a study could also be structured to compare oil-fueled and coal-fueled plants. If no elevation in risk was apparent among communities served by a particular type of plant, this result would be important reassurance that a significant threat to health would be unlikely. Until such a study is conducted, the potential health effects of modern fossil fuel power plants on their local and service communities can only be conjectured.[29]

Demographic Changes: Community Health Impact

The Western United States, particularly the rural desert and Rocky Mountain areas where coal production will be concentrated, have some superficial similarities to the Appalachian mountains, the traditional center of American coal mining. The economic and cultural activities are centered in small towns, and medical care—particularly at the secondary and tertiary tiers—may be poorly accessible.[30] Adequate housing and water supplies may be scarce. These and other pertinent community health problems have been described in detail for the rural West[31] and are shared by Appalachia.[7] On the other hand, there are important differences between the two regions: the West has been more affluent, has been more heterogenous in its population and economy, and has experienced an influx of population rather than the outward migration that has characterized Appalachia until recently.[7] Thus despite some superficial similarities morbidity trends of present

coal mining communities cannot be extrapolated to the West uncritically. The situation most comparable to the Appalachian experience is likely to be that of the rural Indian population or other rural minorities. Indians constitute a large fraction, frequently the majority, of the work force in power plants and facilities in parts of the Southwest. The Black Mesa mine, for example, is located on the Hopi reservation and employs many Navajo. Health planners should be aware of the special needs and problems of such communities.[31]

The massive expansion of coal mining, processing and utilization will lead inevitably to a type of community characteristic of the American West—the boom town.[30] This phenomenon was not considered by the Advisory Committee report and is a significant omission.[4]

A boom town is a small, isolated community which suddenly experiences rapid economic development, usually due to the exploitation of natural resources or tourist appeal. The rapid population influx severely strains municipal services (particularly schools), land use planning, mental health clinics and pollution control enforcement. Control over a boom town's growth and development increasingly falls to governmental and economic forces outside the local community structure. These outside forces may not be sensitive to concerns over the adequacy of local services and the quality of life in the community. Studies of these situations have emphasized the economic and crime problems of an expanding population served by a lagging infrastructure (the physical resources and social organization of a community). The work that has been done on this social phenomenon has been based largely on Western coal mining and power generating communities, so that the model is directly applicable to the problem of expanded coal utilization.[32,33] Unfortunately, the health implications of boom towns have not been closely examined.

Given the present high capital costs for providing medical services in small rural communities[31] and the initial drop in *amenity benefits* (level of services to the individual resident proportionate to taxation and revenue) that accompany boom town development,[33] it is clear that medical, public health, sanitation and pollution control services may lag seriously behind economic growth in many coal-dependent boom towns. Preliminary data from Montana suggest that this process of community degradation has already begun, even this early in the development of the state's coal resources.[30]

Public discussion of expanded coal use in the West is now increasing as a result of publicity and political attention.[1,2,22,30] This public debate comes at a time when commercial development and policy execution are already underway, however. There has been no systematic effort to seek citizen response in advance, although the character of the region will be profoundly changed by those developments. In the absence of such preparation, the public debate is only now taking shape. The health implications of these developments are important aspects of the debate.

Lacking specialized public health training and very seldom experienced in regional planning issues, most physicians are ill-equipped to participate in the discussion, even on the local level. This is unfortunate, because the design and planning of communities and patterns of economic use may profoundly affect the health of residents and their access to health care. Trained health professionals with expertise in planning, or a relatively few physicians prepared to become familiar with the discipline of urban and regional planning, might contribute substantially to the planning process and would assist the public debate.[34]

Conclusions

In addition to the formal recommendations of the Advisory Committee report, several supplementary suggestions merit consideration in shaping public policy on Western coal utilization. Most of these suggestions would require federal action, but a few are within the capacity of state and local authorities to implement.

- Much wider public discussion on the issue of expanded coal utilization is needed in the Western states.
- Medical and health professionals should become involved in community and regional planning processes well ahead of the implementation of proposed projects.
- More trained professionals are needed to guide development and to provide epidemiologic and environmental analyses.
- The Environmental Impact Statement, required under the National Environmental Policy Act of 1969, should be refined into a baseline

survey of environmental and health conditions with proposals for monitoring changes.

- A major research effort should be supported to assess the potential health risks of coal processing technologies; that is, gasification and liquification.
- Selected representative Western coal mining communities should be prospectively studied to monitor the health, economic and social impact of coal activities.
- A large-scale epidemiologic survey to compare the community health effects of coal-fired, nuclear and other power stations should be organized and supported.
- Untoward effects of the boom town phenomenon should be considered in formulating policy within the National Energy Plan and assistance should be considered for communities experiencing a disproportionate share of the burden.
- The National Energy Plan should be open to modification if a substantial health problem is encountered.

The National Energy Plan cannot be solely an economic development plan because its effects are too far-reaching in other areas of national life. The social and health effects of its implementation should be anticipated and controlled as well as possible. The Advisory Committee report was an important exercise in technology assessment and environmental health. Perhaps these additional suggestions will bring about further critical discussion of the implications of such massive projects. Much remains to be done to prepare for the coming impact and to channel the development toward constructive ends. The time to prepare is now; the momentum of economic development has already begun.

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